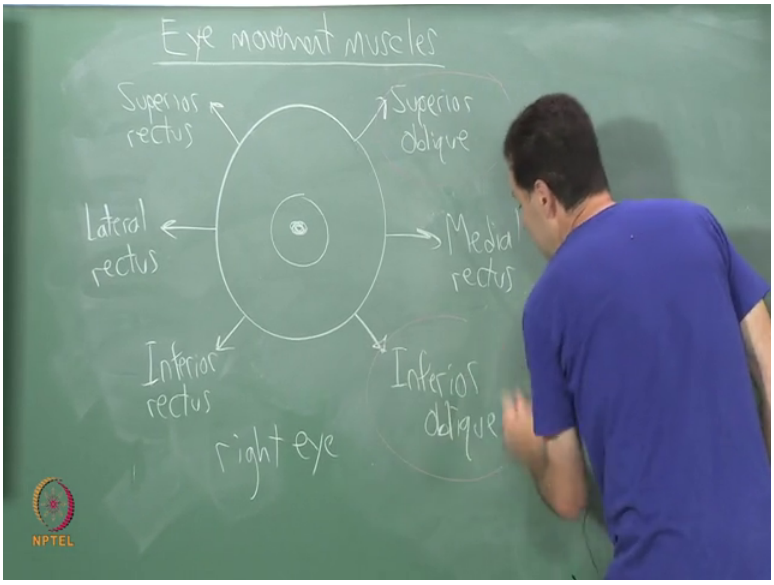
Virtual Reality
Prof. Steve Lavalle
Department of Multidisciplinary
Indian Institute of Technology, Madras

Lecture – 10
Human Vision (eye movements, cont'd)

Welcome back. Let us continue for the next lecture. We are continuing onward with the topic of the human eye and the human vision system and so, last time, we finished talking about a different kinds of eye movements, I went into a bit of detail on saccades and smooth pursuit. I am going to cover eye other eye movements in just a moment. I first want to make a quick correction that was pointed out during the break.

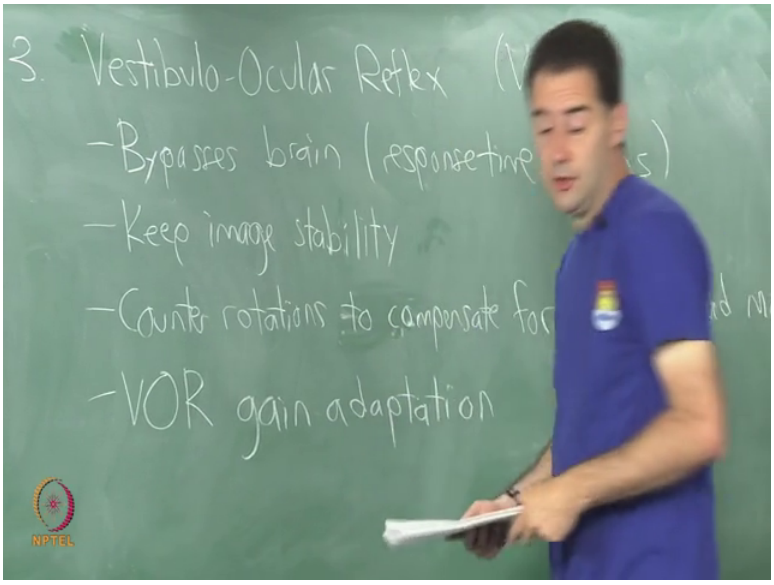
(Refer Slide Time: 00:47)



So, I gave these 6 different eye muscle names and these 2 superior oblique and inferior oblique I had them swapped in the previous lecture. So, this is the way they should be superior means on top and inferior means below. So, that is all. So, I just had these inverted; rest is correct.

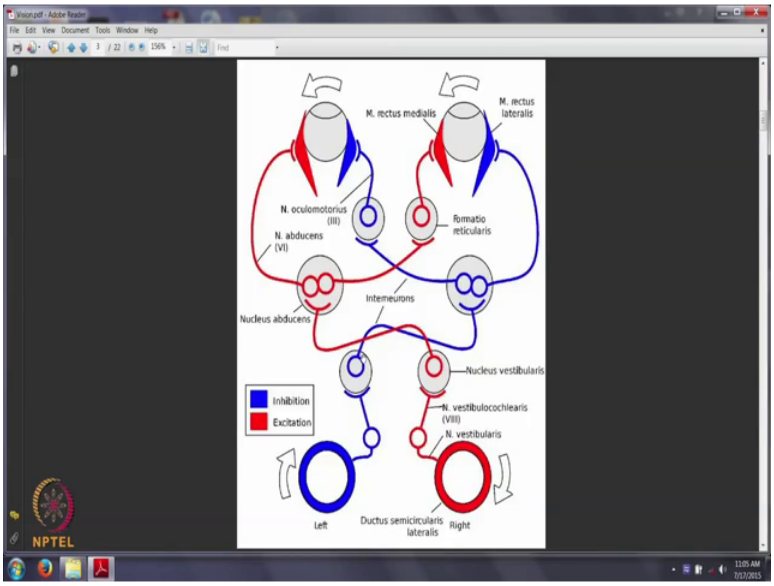
So, eye movement number that I want to talk about is the vestibulo ocular reflex you can see it has the word vestibulo in it.

(Refer Slide Time: 01:09)



So, this is sometimes it is abbreviated as VOR and it is called the VOR. So, pronounced letter by letter here is a diagram showing how the vestibule ocular reflex works as part of our physiology.

(Refer Slide Time: 01:30)

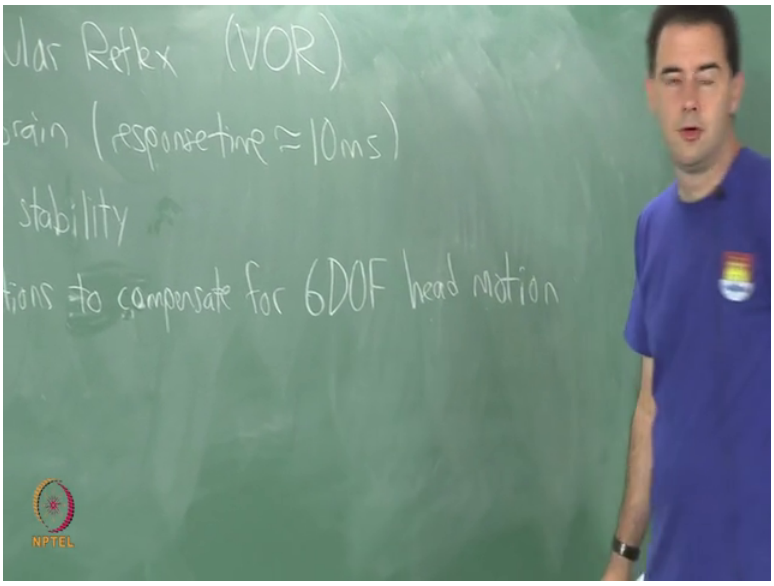


And these circles in the bottom correspond to canals inside of our vestibular organs. So, there inside your ear canal and there measuring angular accelerations and. So, for example, you have the right vestibular organ and that is connected through a very short kind of loop. Let us say that does not use your higher level brain functions at all a very tight loop. It controls these left eye muscles and then your left vestibular organ is controlling the right eye muscles. It is exactly these muscles that we drawn on the board therefore, the eye movements and in less than 10 milliseconds of delay, you get these eye; move eye rotations that counter the rotation of your head. There is also translational movement as well.

So, it is even occurring when I do this. If I just translate my head back and force without doing any significant rotating, but the important thing is the most common thing is that when I put an object in front of me and I go back and force like this I have the vestibulo ocular reflex working for me that is causing me to perceive this as stationary and it is again stabilizing images on my retina for that; right.

So, in one case, the smooth pursuit; it was the object of interest that is moving while the viewer is remaining still and in this case, it is the viewer whose moving and the object is remaining still of course, you can imagine some combinations of motion of both, but I am just trying to separate them out nicely. So, it is fascinating that it bypasses the brain used to higher level parts of the brain.

(Refer Slide Time: 03:34)



So, the response time is around 10 milliseconds which makes it the fastest reflux in your body purpose is to keep image stability can imagine right away, if you have a virtual reality headset that has a lot of flaws and with regard to latency pixilation; all sorts of things going on this reflex is trying to maintain image stability and you are interfering with it by presenting this artificial stimulus trying to fool your brain if you do not get it right your perceptions of stationarity are not going to be matched perfectly.

So, you get a counter rotations and also translations or you get counter rotations to compensate for the 6 degree of freedom head motion, right. So, you getting rotations because of these high movement muscles being connected to the vestibular organ and. So, all we can do is rotation right I cannot translate the eyeballs inside of our heads. So, it is doing rotations to compensate for full 6 degree of freedom motions while I remain fixated on something here is something fascinating that happens you should definitely be aware is very important for virtual reality, it is called VOR gain adaptation.

So, in this case I am looking at this bottle and I move my eyes accordingly with the vestibulo ocular reflex as I rotate my head the counter rotation rate of my eyes is exactly matching the rotation rate of my head right. So, it is a perfect one to one correspondence that corresponds to a gain of one, if I were to put on some glasses and then do this very quickly I would perceive the bottle as swaying back and forth, we would call that a swimmy kind of motion.

Now, for those of you who are wearing glasses for a long period of time if you do this experiment the bottle should look stationary and. So, what is happening is the optics of your glasses are causing a distortion, but your brain is learning to compensate for that. So, your vestibulo ocular reflex; this gain parameter will adapt and change to your glasses if you take your glasses off immediately and then do this you might see the real world an object in the real world looking like it is not stationary which is quite incredible right, if you put on a virtual reality headset where the optics have distortion in them and it has not been correctly compensated your brain may adapt to that and then when you take the headset off and you do this in the real world the real world might look like it is swimming back and forth.

So, when I was doing development and oculus I saw this very frequently I would have I would spend hours trying to fix a distortion tracking other kinds of and then I would go look at the menu board for lunch turn my head back and forth and the menu board looked like it was swaying back and forth I was not right and I started to really question reality in many ways a very strange to have this happen. So, these things are somewhat invisible to us there happening all the time if you wear glasses you know these things are happening it is a question, yes.

Student: Yes sir we are saying that we can compensate for 6 duos of head, but I have only 2 duos. So, how can I compensate it?

Let us see. So, we have we are compensating for 6 degrees of freedom of head motion, but we only have.

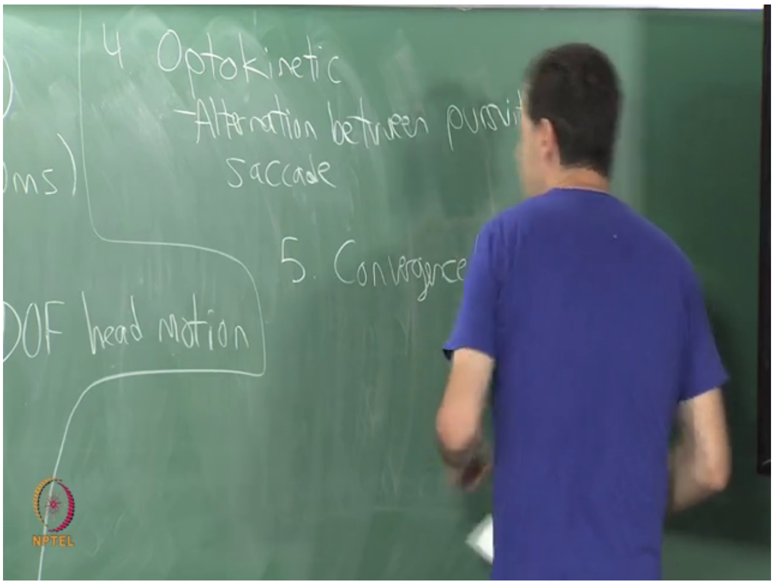
Student: 2 degree.

2 or 3; 3 degrees of freedom I guess right with the eyes in general I guess, right, but I guess we cannot compensate completely in some cases right. So, that is a good observation there is more degrees of freedom in the motions than there are in the in the possible rotations that we can apply that is correct let us see. So, maintaining visibility of you while eye move my head and body around that is a good question what is really wrong here how many; it is interesting; it is one of doing these motions.

It is very hard, I guess I have to think about designing a particular motion that is going to be hard right if I do that I think my VOR is not working very well anyone want to try to do some very strange figurate motions like that I do not feel too well now. So, I think that it is possible to design some complex motion patterns that cannot be compensated directly by the VOR that is my guess to your answer, it is a great question I have not considered that before anyone else I did sort of energize everyone towards paying attention to degrees of freedom very carefully.

So, you did that well that is it is good question. I should have anticipated it lets see.

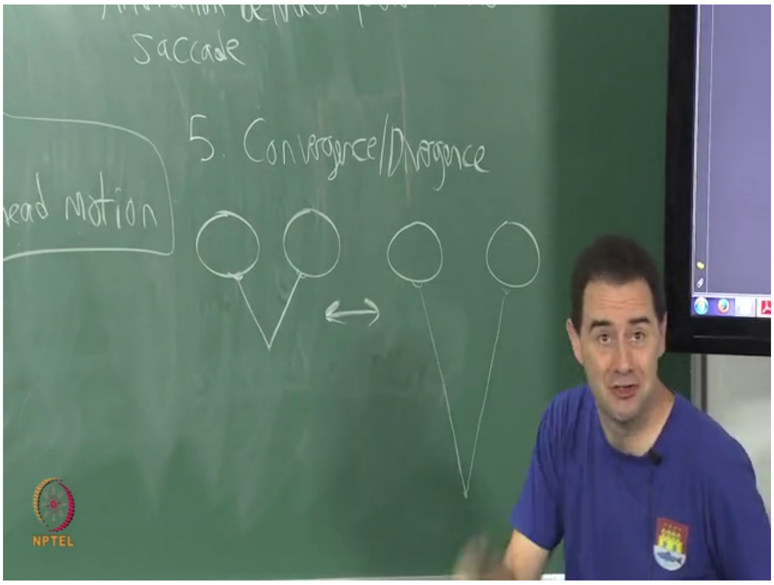
(Refer Slide Time: 09:01)



So, another case 4 is optokinetic and this is an alternation between pursuit and saccade and the reason why this happens is for a very fast-moving rather large object that you may want to track and you keep jumping from feature to feature on it. So, the most common example I can think of as you are standing on the ground and you are watching a train go by. So, your brain will go into a mode where your vision system will go into a mode where it tracks a feature on the train then jumps to another one and then jumps to another one you ever do this before I do not find it very comfortable at all.

But nevertheless it is interesting to watch a fast moving train when you are fairly close to it is everyone done this before. So, this is some kind of mode I cannot think of too many more examples where this occurs and let us see example 5; it is a convergence and upper divergence together. Now you put divergence; there I am not saying that your eyes are diverging outward when you are looking all right some people may have such a condition, but what I mean to say is that when I am converged and they are looking together then when I look at an object that is far away they diverge, right the motion is diverging. So, your muscles are either pulling them towards convergence or pulling them away towards divergence. So, that is 2 different 2 different directions, but it is the same phenomenon.

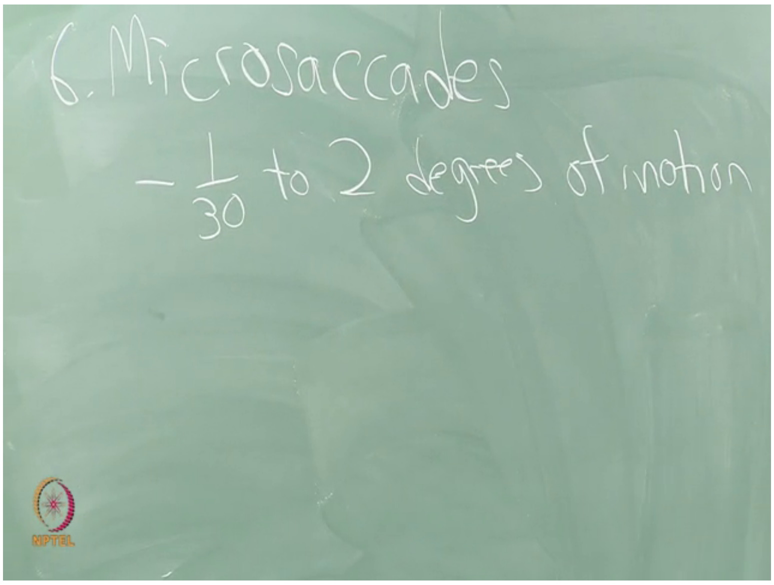
(Refer Slide Time: 10:57)



So, may have my eyes rotated to look at something very close or not rotated together as much not oriented together as much to look at something far away. So, it is these motions between these 2, right.

So, if I go this way that I am converging if I go the other direction then its diverging, but it does not mean the result is fully diverged the eyes are converged in both cases right until the extreme case when you are looking at something let us say add infinity, then they should be parallel; let me see around this and I have one final case to cover. This is the most mysterious; I think much very much is mentioned about it in the book, but there is a lot of current literature on it is called micro saccades that is number 6.

(Refer Slide Time: 11:59)



So, these are tiny motions; they are around one thirtieth to 2 degrees of motion there involuntary and this may be one of the reasons why I showed you some images in the first class and one of the images I showed you had look like some kind of fractal pattern and it looked like it was moving all by itself, but clearly it was not moving and micros saccade might be one of the reasons for this.

So, I have done some research on this I found half a dozen different possible explanations of what micro saccades are good for some of them may have to do with further stabilization perhaps refreshing photo receptors that have become saturated over time all sorts of possibilities, but largely researchers are debating this over the last few years, but just something to point out there are all these additional motions.

So, the amount of instability in images that are falling onto our retinas I really find astounding and the brain is compensating for all of that. So, so the micro saccades category could have a half a dozen sub categories where micro saccades are occurring for various purposes these have been known for a very very long time Robert Darwin father of Charles Darwin actually discovered them first; so, in the 19th century. So, very long time they have been known, but we still do not have an explanation of what exactly they are they are good for why are they occurring they are clearly intentional it is not some kind of accident it seems.